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On the PHYSIOGRAPHIC IMPROBABILITY of LAND at the NORTH POLE.

BIBLIOGRAPHY of SUB-MARINE VALLEYS OFF NORTH AMERICA.

By J. W. Spencer.

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Art. XXXIV.—*On the Physiographic Improbability of Land at the North Pole;* by J. W. Spencer, A.M., Ph.D.

The earlier explorers had little to guide them, but they brought back occasional soundings, which seemed to indicate a shallow Arctic basin. The drift wood suggested that it was a more or less open sea, beneath the ice floes, even though its depth might not be great. Some soundings were of unusual depth, but their importance, not being known, was entirely overlooked. The soundings in the Arctic region were insufficient of themselves to suggest their own explanation, before the character of drowned channels was understood. Indeed, while occasional valleys channeling the submerged border of the continent had been noted by Dana, Lindenkohl, Milne-Edwards, Davidson, Issel, the present writer, Upham, and others, the systematic study of these features really dates back only to 1893–4, resulting in the publication of the "Reconstruction of the Antillean Continent."* This has been the pioneer of many subsequent contributions on submarine valleys and drowned plains. The same features have been studied on the western side of Europe by Prof. Edward Hull,† and in the Arctic region and farther south by Prof. F. Nansen.‡ Accordingly the features of submarine valleys channeling the edge of the Continental mass are now pretty well understood, so that we can interpret even the limited amount of data already obtained in the Arctic region and have some reasonable understanding of the phenomena which they indicate.

I was in northern Norway when the Ziegler expedition sailed, and hearing of their expectation of finding Polar land,

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* By the present writer, Bull. Geol. Soc. Am., vol. vi, pp. 103–140, 1894.

† Numerous papers, mostly published in Trans. Victoria Institute, London, 1898–1902.

‡ On Bathymetrical features, Continental Shelves and Oscillations, Christiania, 1904, pp. 232, plates 28.

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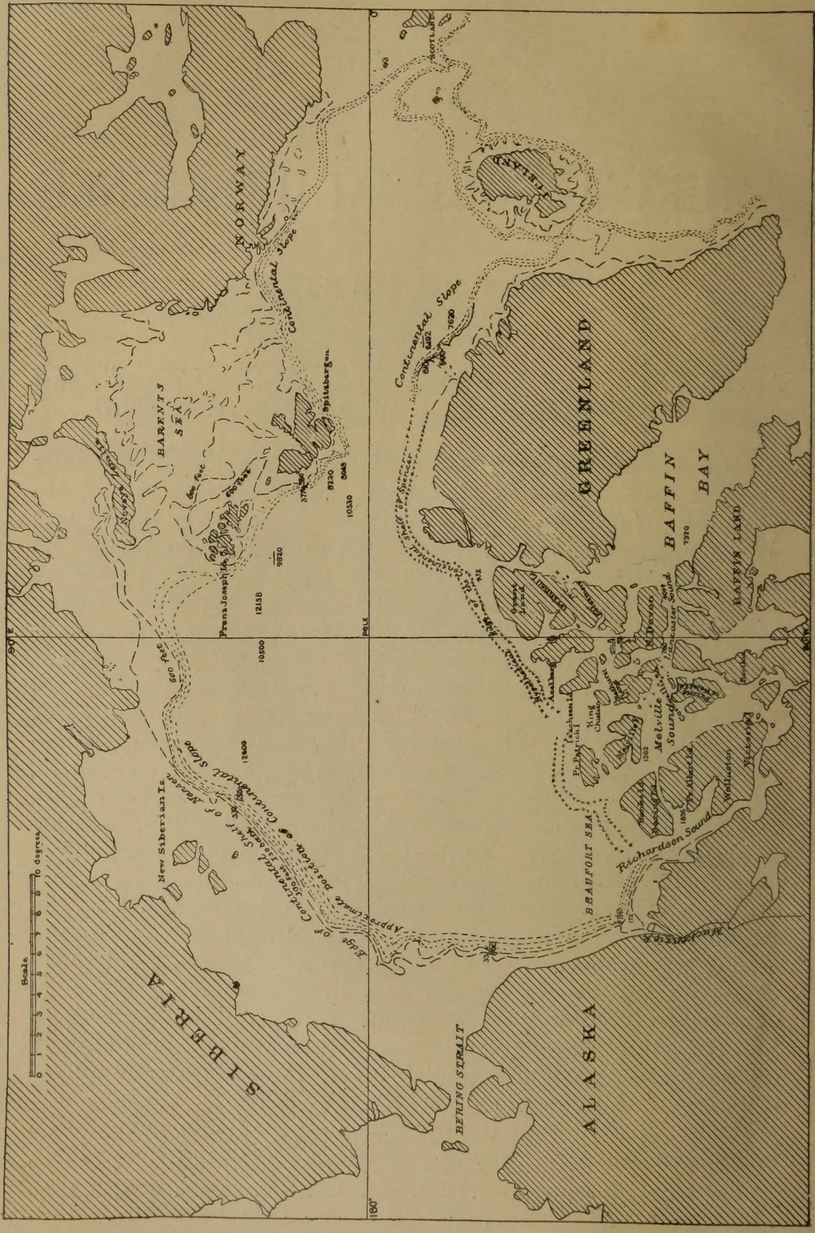
NORWAY
BARENTS SEA
Nova Zembla
Franz Josef Land
Spitzbergen
Continental Slope
ICELAND
SCOTLAND
GREENLAND
BAFFIN BAY
BAFFIN LAND
N. Devon
Melville Sound
Pr. Patrick
King Christian
Wollaston
Victoria
Richardson Sound
BEAUFORT SEA
ALASKA
BERING STRAIT
SIBERIA
New Siberian Is.
Nansen
600 feet
POLE
12138
9820
10530
10500
12000
7620
7320
90°E
180°
0
Scale
10 degrees

I felt that disappointment was in store for them; for Dr. Nansen's great discovery of a profound Arctic basin, immediately beyond the border of the continental shelf, precluded the probability of finding land between Franz Joseph Land and the Pole, or indeed along this line for a thousand miles beyond, until approaching the embouchure of the Mackenzie River, although to the left of this line the continental shelf north of Greenland, bearing perhaps an island, might extend far polarward. Nansen had found the Polar basin to reach a depth of 12,000 feet or more. This would have to be crossed by any expedition from the European side and here no portable sounding apparatus could be effective until approaching the American shelf beyond the deep basin itself. But had the undertaking been made from Grant Land, soundings to a depth of 3000 feet or less would have surely revealed the rapidly increasing depth of the slope from the continental shelf to the abyss of the basin, out of which no land could be expected to rise. Thus the character of the Polar district would have been discovered, perhaps without reaching to within some hundreds of miles of the Pole, depending upon whether the shelf extends far north of the known land or not. If the Ziegler expedition were for the purpose of adding to our knowledge, it is to me astounding that the route chosen should have been approved of by the advisers, knowing of the deep sea north of Europe, even without such analysis of the subject as has since been published by Nansen, or is here set forth. If the voyage were only one of adventure to reach an icy Pole without any ostensible scientific object, then I give no opinion as to the route taken. These remarks directed to an actual expedition would equally apply to the proposed one of the Duke of Orleans. They are written in the hope that future Polar explorers will take cognizance of the scientific submarine topography, avoiding useless expeditions and devoting their efforts to extending scientific knowledge.

To define the features around the Arctic basin, I should draw an axis from Cape Bathurst, passing close to Bank's Land, Prince Patrick's Land, the Pole, and on to Franz Joseph Land and Novaya Zemlia, thus dividing it into two unequal lobes. The one on the Siberian side is bounded by low lands, with few islands, all of inconsiderable height in front. The confines of the other lobe have bold features in the mountainous islands of Novaya Zemlia, Franz Joseph Land, Spitzbergen, North Greenland, Grinnell Land, Sverdrup's New Land to Prince Patrick's Land and Bank's Land, which have less abrupt features.

In front of the Siberian plains and north of Bering Straits, Dr. Nansen has shown from his own and other soundings that the continental shelf has a breadth of 300 or 350 nautical miles (see map). Its outer margin is at a depth of 300 feet, beyond which is the rapid descent of the continental slope. In front of Spitzbergen, and apparently adjacent to Franz Joseph archipelago, the shelf has a breadth of only about 30 miles. Its border recedes and forms an embayment east of Novaya Zemlia. North of the New Siberian Islands, Nansen found that the submergence of the continental slope increased from about 300 feet to 6000 feet in 30 miles. A similar gradient has been found adjacent to Spitzbergen. Soundings in sufficient numbers have been taken to establish the existence of the broad shelf, with a few others suggesting its border, as for instance, where in proceeding outward the sea suddenly deepens from 300 feet to 700–800 feet. Thus defined, Nansen's map shows a direct line in front of Bering Straits to north of Alaska. Here the continent encroaches upon and greatly contracts the shelf,—an important analytical feature. The shelf appears to be reduced to a breadth of perhaps 40 miles. The Arctic basin does not approach Bering Straits, which is only a shallow lateral trough from the basin itself, but ends in Beaumont Sea, between Prince Patrick's Land and Alaska, where the Mackenzie River, after passing through its own broad embayment or delta, extends to a submarine valley discovered, so far, to a depth of over 1140 feet beneath sea level, thus deeply incising the shelf. In the broad channel between Bank's and Baring Lands and the continent, which (unless it is otherwise named, and the charts do not show it) might appropriately be called Richardson Sound, after its explorer (1848), the submarine valley has a depth of 1836 feet, near the head of a branch fjord, at a point 175 miles within the line of the islands.

Lower down the sound are a number of deep soundings, but they do not reach the bottom in the central axis. Beyond, in McClure's Strait, which separates the eastern side of Bank's Land from Melville Island, the fjord attains a depth of 1362 feet and more, at a point 200 miles within the line of the islands. Here we have found the evidence of deep submarine valleys or fjords entering Beaumont Sea from three different directions, and very much deeper than the submergence of the great continental shelf of the Arctic basin. Further proof is not needed to establish the fact that Beaumont Sea is a broad profound valley leading to the Polar basin, though the depth is not known. Also, that the continental shelf is deeply channelled by the valleys. Now, as we have learned from the analysis of the submarine valleys or fjords off Norway and both coasts of America, the border of the continental shelves does not usually exceed a distance of more than from 40 to 100 miles beyond the outer line of the land or islands. Off

Spain and Portugal the shelf is reduced to 6–20 miles. While the Norwegian channel is much longer, yet it hardly forms an exception to the rule, for the edge of the continental shelf, even here, is within the line of the land between Scotland and Norway. Even now we have sufficient data to show that the edge of the lower platform at a depth of 1200 feet (like in Barentz Sea) does not exceed a distance of 60 to 100 miles from land off East Greenland and in Baffin Bay. From my familiarity with the study of continental shelves, the margin of that beyond even the lower part of Prince Patrick's Land should not be expected to extend more than a hundred miles, if indeed so much, with such a deep channel extending far within the line of the islands. Neither the Mecham nor the McClintock expeditions found land beyond the northern side of Prince Patrick's Land. These fjords are in the western side of the archipelago. Four hundred miles farther east (south of the western end of North Devon) in the head of Lancaster Sound we find another fjord with a depth of 780 feet deepening in 150 miles to over 4000 feet at a point 50 miles within the line of the islands, while other soundings show the shelf to attain a breadth of only a few miles in this part of Baffin Bay adjacent to the deep fjord, but elsewhere it reaches to 100 miles. About 160 miles north of Lancaster Sound, in Cardigan Strait, on the Arctic side of the *col* between North Devon and North Kent, the depth of the fjord exceeds 2400 feet. This point is situated about 250 miles within the line of Sverdrup's New Land, showing that here is another deep channel trending to the Arctic basin. Now with even the few soundings before us (and there are many more not cited here) the fjord-like character of the archipelago cannot be questioned. It is a dissected plateau region (much of which is now 2000 or 3000 feet high, subsequently submerged in part—a region fashioned by atmospheric agents whether now above or below sea level. As the depths mentioned are far within the land line, and in the case of one sound a depth of over 4000 feet occurs even 50 miles within the land line, there is every reason to expect similar depths nearer the mouths of the other fjords mentioned. Where the submarine valleys have attained considerable depths within the land line the shelf should be relatively narrow; and judging from the position of Sogne fjord (nearly 4000 feet deep) I should not expect to find the breadth of the shelf exceeding 50 miles in front of Sverdrup's New Land, as much of the region is a weatherworn plateau. One sounding north of Grant Land strengthens this view. At about 30 miles off the land the sounding shows 432 feet, somewhat in excess of the submergence of the Arctic continental shelf wherever known off the Siberian coast. It would seem that the edge is being approached. Nansen has pointed out the remarkable uniformity of the shelf in the Polar basin. Continental shelves are characteristically narrower in front of bold highlands than where they fringe low plains as on the other side of the Polar basin. Apparently the question of the formation of the continental shelf in one part of the Arctic cannot be separated from the rest of it. No land was discerned beyond Prince Patrick's or from Sverdrup's New Land.

From the absence of land for a hundred miles, from the occurrence of the sea depth at 432 feet thirty miles from land, and from the characteristic of narrow shelves in front of high lands, I suspect that Commander Peary passed the edge of the shelf and was perhaps over the deep basin, as he would have been in front of Spitzbergen. From this consideration and from the feature of limitation of the continental shelves being indicated by the presence of deep fjords as found among the islands of the archipelago, and from the characteristics of the platforms in front of high lands, I am inclined to place a theoretical limit of from 50 to 100 miles as the breadth of the shelf in front of the known islands, without the expectation of finding any great islands farther north. If this approximation, based upon physiographic information of no mean value, be correct, there would still remain a distance of 300 or 350 nautical miles between the edge of the shelf north of Grant Land and the Pole, beneath the ice of which obtains the deep basin. The edge of the shelf, indicating the limit of the insular extension of continental lands, wherever found, precludes the probability of land beyond, rising out of a deep sea basin.

Having found a working hypothesis from the physiographic features, other phenomena in support of the hypothesis based on the submarine topography have been mentioned by Dr. Nansen. Along the course of the Fram, at depths of more than 800–900 meters, colder heavy bottom water was found, above that affected by subterranean heat, but beneath the overlying stratum of warmer water. It must have cooled down somewhere in the unknown Arctic basin, in contact with the cold surface water; and this place of wide extent is somewhere far from the course of the Fram, occupying probably the greater part of the still unknown Polar region. Similar phenomena exist in the Norwegian Sea, where, however, the center of cold has been found. The drift of the ice under the coast of Greenland is much greater than where the ice belt is broader in the Polar sea. These additional phenomena further preclude the idea of Polar land.

I have not touched upon the question of possible land north of Bering Straits. The position is much farther from the Pole than that of the locations considered. Nor has the question of tides been referred to. This last has been ingeniously discussed by Dr. R. A. Harris.* According to him, the currents set eastward and westward from Bering Straits, which he thinks is caused by land to the north. The tides coming from the east of Greenland (rising two feet) recur near Bennett Island, north of the New Siberian, with the same range. The drift of the Jeannette was accelerated on approaching this locality as if a broad strait were situated here. On the coast of Alaska, the tide is reduced to a few inches, caused, Dr. Harris thinks, by the interference of a large land area. Now Bennett Island is more than 100 miles within the border of the continental shelf. Nansen crossed its edge 200 miles northwest of this point, so there is room for an island of considerable size without the shelf protruding beyond its general outline. Although the outline of the shelf, north of Bering Straits, seems to have been approximated, there may be in front of it a secondary platform, on which remnants of a higher one, surmounted by land, occur with characteristics resembling rather the New Siberian archipelago than Spitzbergen, although this last mass partly rises above a lower platform, as would be the case with part of the hypothetical islands north of Bering Straits. It is only on an extension of the continental shelf that the occurrence of land could be expected, and any great extension of it would disturb the symmetry of its outline, a point which should not be overlooked. If the phenomena described by Dr. Harris really demand a great land mass, physiographically there is no reason why there should not be even a nearly continuous chain of islands from near Bennett Island extending towards Prince Patrick's Land, though it could not occur in front of Beaumont Sea. But I find no ground here for extending land nearer than ten degrees of the Pole. Islands would satisfy the tidal currents off Alaska according to Dr. Harris, though it might not explain the tide rising two feet to Bennett Island. My conclusions agree with those of Sir Clement Markham, quoted by Dr. Harris:—who "does not believe in any land near the Pole, but believes there is land probably in the form of large islands between Prince Patrick's Land and the New Siberian Islands." I should limit their occurrence to a line directly connecting these islands, with no important additions, to the American archipelago, a theory suggested by the enclosed fjords. An island may exist near Simpson cove as suggested by Dr. Harris, perhaps constituting the end of a chain from Bennett Island skirting the edge of the continental shelf.

If I were permitted to plan out an expedition for the purpose of adding to our knowledge of Arctic physiography, it would be somewhat on the following lines, so far as physical conditions would permit. Two expeditions have reached Prince Patrick's Land. Another might enter by Bering Straits, skirt the ice and make close soundings in Beaumont Sea, discover the deeper canyon of Mackenzie River, explore to the bottom Richardson Sound and the channels to Prince Patrick's Land. If the ship could not be drifted past this place, a land and over-ice party with portable sounding apparatus, for depths of 500 fathoms, or if possible a little more, should make the utmost effort to reach a point where the water had either such a depth, or land were found, if the sea continued shallow beyond expectations. A hundred miles have been crossed by Peary; probably so long a journey would not be needed. If the ship could be drifted in the ice north of Prince Patrick's, the sound between this land and Sverdrup's New Land should be explored, for islands or open sea. Else the ship might have to follow the old route through Melville Sound, with an effort to revisit Isachsen Land (one of Sverdrup's New Lands), carrying the ship, or repeating the over-ice sounding expeditions to determine the border of the continental shelf. Such a program should be continued to north of Grant Land, various points of which have been visited, even if the ship could not be worked or drifted in the ice. North of Grant Land, and also Greenland, should be revisited as by Commander Peary, but carrying the sounding apparatus, so that when the edge of the continental shelf shall be reached, the explorer would know when his work was finished and avoid useless adventure. Such an expedition, perhaps requiring several years, should be made to round off Polar explorations. It seems to me to be the only one promising great results, at least of a finishing character. Explorations north of Bering Sea would be farther away, and I have no suggestions to make except to sound well the region traversed, by the ship or sledge party attempting a further voyage.

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* Nat. Geog. Mag., vol. xv, pp. 255–261, 1904.

This little paper is only an application of the study of the deep channels trenching the eastern coastal plains of the continent; which study throws much light upon the subject of the physiography of even the Polar regions. There is also an economic aspect of the question of such submarine physiography, as in the laying of cables, so that they will not swing over the precipices of drowned canyons and consequently collapse. Prof. Davidson has reported ships lost by not being able to drop anchor during storms through being unaware of the adjacent shoal waters, outside of the limits of the drowned channels.

ART. XXXV.—*Bibliography of Submarine Valleys off North America*; by J. W. SPENCER.

Papers on the Submarine Valleys indenting the Continental Shelf off the American Coast and in the West Indies; by J. W. SPENCER.

THE appearance of the "Submarine Great Canyon of the Hudson River" has emphasized the absence of easy reference to the scattered contributions where those interested have not continuously been giving the subject their attention. In this case, it may be expressed in the language of a gentleman, a stranger to the writer, who says that he is "now much interested in this particular subject, but has been unable to get hold of any matter regarding it otherwise than a vague popular sketch here and there which has left him about as much in the dark as though he had read only the title." Some of the papers are not of recent appearance. Others have been published abroad. This condition is perhaps sufficient reason to assemble the list of the papers. The subject is one of equal interest in Europe as here, where there would be a greater difficulty in knowing what had appeared on this side of the Atlantic.

In order to call the attention of the American student to what has been done by Prof. Edward Hull and Prof. Fridtjof Nansen, I have prepared somewhat lengthy summaries of their contributions on this subject, as these are more difficult of access here. The writer's investigations are the slow outgrowth of his studies of the origin of the basins of the Great Lakes, which will not be further referred to here. Otherwise, as bearing on the Atlantic border the investigations began with:

1. "High Continental Elevation preceding the Pleistocene Period;" Bull. Geol. Soc. Am., vol. i, pp. 65–70, 1889; Geol. Mag. Lond., III, vol. vii, 1889. (This contains a description of the submarine valleys of the Gulf of St. Lawrence and of Maine to depths of over 3000 feet. The former is now known to be over 5500 feet.)

2. "Terrestrial Subsidence Southeast of the American Continent" (a preliminary notice of the next paper) with map. Bull. Geol. Soc. Am., vol. v, pp. 19–22, 1893.

3. "Reconstruction of the Antillean Continent" with map. Bull. Geol. Soc. Am., vol. vi, pp. 103–140, 1894–5. (Here is a description of the submarine valleys extending beyond the buried channels of great land rivers, and trenching the continental shelf to abyssmal depths, from Cape Hatteras to the Gulf of Mexico and in the Caribbean Sea. The evidences therefrom indicate great Pliocene and Pleistocene elevations, and the land connection of the two Americas. This is the first constructive paper

on the subject, and together with the discussion of the bearings is the foundation of the subsequent work.) Abstract in Am. Nat., vol. xxviii, pp. 881–884. Also an important "Note on Mr. Kummel's review," concerning the gradient of the valleys. Jour. Geol., vol. iii, pp. 497–498, 1895.

4. "The Yumuri Valley of Cuba—a rock basin." Geol. Mag. Lond., IV, vol. i, pp. 499–502, 1894.

5. "Preliminary Notes on the late Connection and Separation of the Pacific Ocean and Gulf of Mexico," Ib., vol. ii, pp. 306–308, 1895.

6. "Geographical Evolution of Cuba," Bull. Geol. Soc. Am., vol. vii, pp. 67–94, 1896 (with more details of the submarine valleys and their geological relationship, terraces, etc.).

7. "On the Continental Elevation of the Glacial Period," Geol. Mag. Lond., IV, vol. v, pp. 32–38, 1898; Abstract B. A. Rept. for 1897, pp. 651–652. (This contains a notice of the recurrence of the submarine valleys, on both sides of the North Atlantic and in the Arctic Sea. It was preliminary to No. 23.)

8. "Geological Canals between the Atlantic and Pacific Oceans." Abstract preliminary to No. 9. Proc. Am. As. Ad. Sc., vol. xliv, pp. 139–140. 1896.

9. "Great Changes of Level in Mexico and the Interoceanic Connections," Bull. Geol. Soc. Am., vol. ix, pp. 13–34, 1898. (Here is shown changes of level complementary to those indicated in the submarine valleys.)

10. "Late Formations and Great Changes of Level in Jamaica." Trans. Can. Inst. Toronto, vol. v, pp. 324–357, 1898. (With further details of the relationship of the submarine valleys to the land features, of the characteristics of the submarine platforms, of land connections, etc.) Abstract in this Journal, IV, vol. vi, pp. 270–272, 1898.

11. "Resemblances between the Declivities of High Plateaus and those of Submarine Antillean Valleys." Trans. Can. Inst. Ib., pp. 359–368. Abstract this Journal, IV, vol. vi, pp. 272–273, 1898. (Showing the gradients of both kinds of valleys by steps, an important supplement to the Antillean paper, No. 3.)

12. "The West Indian Bridge between North and South America," Pop. Sc. Monthly, vol. liii, pp. 10–30, 1898.

13. "Geological Waterways across Central America," Ib., pp. 577–593.

14. "Prof. Hull's 'Submerged Platform of Western Europe.'" Geol. Mag., Lond., IV, vol. vi, pp. 16–18, 1899.

15. "Mr. Huddleston's 'On the Eastern Margin of the North Atlantic Basin.'" Ib., pp, 559–566. (A reply to his criticism of Prof. Hull's work.)

16. "The Windward Islands of the West Indies." Trans. Can. Inst., vol. vii, pp. 351–370, 1901.

17–22. "On the Geological and Physical Development of:— Antigua; Guadeloup, Anguilla, St. Martin, etc.; St. Christopher Chain and Saba Banks; Dominica; with notes on southern islands, Barbadoes and Trinidad." Six papers in Quar. Jour. Geol. Soc., Lond., vol. lvii (1901), pp. 490–544 and vol. lviii, pp. 341–365. (The local development of the insular shelves, the submarine channels and valleys, and their associated geological and physiographic relationships are considered, while in No. 16 they are further correlated.)

23. "The Submarine Valleys Off the American Coast and in High Latitudes," Bull. Geol. Soc. Am., vol. xiv, pp. 207–226, 1903. (This is an amplification of No. 7 and a delayed continuation of the paper on the Antillean Continent, No. 3.)

24. "The Submarine Great Canyon of the Hudson River," this Journal, IV, vol. xix, pp. 1–15, 1905. (The most perfectly explored of all the American canyons.)

25. "On the Physiographic Improbability of Land at the North Pole," as in this Journal preceding this list. (An application of the study of Submarine valleys to exploration of the unknown Arctic region.)

26. "Prof. Hull's 'Sub-oceanic Terraces and River-Valleys off the Coast of Europe.'" A Review. Am. Geologist, vol. xxxv, 13 pages (in press), 1905.

27. "Dr. Nansen's 'Bathymetrical Features of the North Polar Sea, with a Discussion of the Continental Shelves and the Previous Oscillations of the Shore-Line." A Review. Am. Geologist, vol. xxxv, 15 pages (in press), 1905. In this Dr. Nansen discusses American valleys.

The study of the submarine valleys is in its infancy, and while the work in the above papers somewhat overlaps and embraces many features, these have been considered incidental to working out the submarine channel, valleys, etc., dissecting the submarine border of the continent. These valleys are regarded of atmospheric origin from the facts brought out, therefore they become evidence of great changes of level of land and sea. Some of the consequences of such changes are considered. But only a commencement of the great problem has been inaugurated.

While references have been made to the work of others in the writer's papers, the addition of the following contributions will make a nearly complete list, so far as America is concerned. As to Europe, the references in the papers of Prof. Edward Hull and Dr. Fridtjof Nansen are equally comprehensive.

Prof. J. D. Dana: "The Hudson River Channel;" in all editions of The Manual of Geology (1863–1895).

"Long Island Sound in the Quaternary Era, with observations on the Submarine Hudson River;" this Journal (3), vol. xl, pp. 425–437, 1890. (In all cases the submarine channels are regarded as submerged valleys.)

Prof. A. Lindenkohl: "Geology of the Sea Bottom in the approaches to New York Bay," this Journal (3), vol. xxix, pp. 475–480, 1885.

"Notes on the Submarine Channel of the Hudson River, and other evidences of Postglacial Subsidence of the Middle Atlantic Coast Region. This Journal (3), vol. xli, pp. 489–499, 1891 (in which the channel was differentiated, with the recognition of the continuing canyon to a depth of about 3000 feet).

Prof. George Davidson: "Submarine Valleys of the Pacific Coast of the U. S." Bull. Cal. Acad. Sc., vol. ii, pp. 265–268, 1887. (Calling attention to the valleys and describing three of them, without discussion of origin.) Others are described in his Pilot of the Pacific Coast, 1889, pp. 35–36, 51–52. (He refers to having later designated them "submerged.")

"The Submerged Valleys off California (U. S.), and of Lower California (Mexico). Proc. Cal. Acad. Sc. (3), vol. i, pp. 73–103, 1897. (Here the Continental Shelf is considered, 31 submerged valleys are described dissecting it, and the features of the adjacent land are given. Several are traced to 2000 feet, one to 3600, and one to 5000 feet below the surface of the sea.)

Dr. Warren Upham: "Quaternary Changes of Level;" Geol. Mag. Lond. (3), vol. vii, pp. 492–497, 1890.

"The Fjords and Lake Basins of North America considered as evidence of Preglacial elevation, and depression during the Glacial Period." Bull. Geol. Soc. Am., vol. i, pp. 563–567, 1890. (He also treats of some foreign examples.)

"Submarine Valleys on Continental Slopes;" Abstract, Proc. Am. As. Ad. Sc., vol. xli, pp. 171–173, 1892.

"Fjords and Submerged Valleys of Europe;" Am. Geol., vol. xxii, pp. 101–108, 1898.

Prof. Joseph Le Conte: In Tertiary and Post Tertiary Changes of Atlantic and Pacific Coast," etc. Bull. Geol. Soc. Am., vol. ii, pp. 323–330, 1890. (Discusses the submerged valleys as such, with their beheading by orogenic movements.)

In "Earth-Crust Movements and their Causes;" Bull. Geol. Soc. Am., vol. viii, pp. 113–126, 1897. (He discusses the oscillations which favored the excavation of land vâlleys, and subsequently submerged them.)

Prof. A. C. Lawson: In "The Geology of Carmelo Bay;" Bull. Univ. Cal. (Geol. Dept.), vol. i, pp. 57–59, 1893, also page 155 (in which he briefly discusses the submarine valleys, believing them to be structural).

Prof. Harold W. Fairbanks: "Oscillations of the Coast of California during the Pliocene and Pleistocene." Am. Geol., vol. xx, pp. 213–245, 1897. (Discusses the submarine valleys, pp. 228–245, with the conclusion that they are submerged land valleys formed in the early Pleistocene days.)

Mr. W. S. Tangier Smith: "The Submarine Valleys off the California Coast," Science, vol. xv, pp. 670–672, 1902. (He suggests that some of the submarine valleys were made or opened by subterranean streams.)

Prof. N. S. Shaler: "Evidences as to the Changes of Sea Level." Bull. Geol. Soc. Am., vol. vi, pp. 141–166, 1895. (Discusses drowned harbors, that of St. Lawrence, etc., subterranean channels of Florida, etc.)